INTRODUCTION

In 2001 the Michigan Department of Natural Resources (MDNR), Western Upper Peninsula Management Unit (WUPMU) staff, Doepker et al, developed the Interim State Forest Management Guidelines to Emphasize Mesic Conifers (MC) in the Western Upper Peninsula (WUP) (Appendix A). These interim guidelines (MCG) recommend goals and silvicultural considerations for increasing the proportion of natural stands of mesic conifers; eastern hemlock, white pine, balsam fir, white spruce and red pine; and enhancing the mesic conifer species component in existing deciduous types, in the four Forest Management Units in the WUP. The WUP interim mesic conifer guidelines were approved by WUPMU Supervisors in Wildlife Division (WD) and Forest, Mineral and Fire Management Division (FMFMD).

The 20 year goal is to increase mesic conifers by 57,000 acres on state forest land in the WUP by 1) enhancing the within stand component of mesic conifers in hardwood dominated forest types; and 2) expanding the mesic conifer forest types. The MCG provide justification and prioritizes objectives for each forest management unit (FMU) by species based on historical extent and abundance for the mesic forest species, existing forest conditions, historical documents and existing environmental conditions including deer numbers.

	Mesic Conifer Species Group			
FMU	Hemlock	Spruce/Fir	Red Pine	White Pine
Baraga	1	3	3	2
Crystal Falls	2	2	1	1
Escanaba	3	1	2	1
Gwinn	1	3	2	1

Priority
1=Highest; 2=Moderate; 3=Lowest

This prioritization only addresses the possibilities for enhancement or expansion of mesic conifers. It does not address the maintenance of existing mesic conifers; for example, maintenance of within stand components and natural stands of hemlock may rate high priority where deer numbers are high, and there is little or no chance of increasing hemlock. The objectives for increasing mesic conifers on state forestland are: 12,000 acres of hemlock; 14,000 acres of balsam fir-white spruce; 10,000 acres of natural red pine; and 21,000 acres of white pine. Refer to Appendix A for the full report on the WUP Interim Mesic Conifer Guidelines.

The recently (2003) formed WUP Eco-team may in time develop a comprehensive ecological management plan for the WUPMU. In the meantime MDNR Forestry and Wildlife field personnel have begun implementing the MCG. In order to facilitate this effort, Robert Doepker, WUPMU Wildlife Supervisor, assigned four WUP wildlife staff to develop a process for an action plan to implement mesic conifer restoration on state lands in the WUPMU. Two FMFMD staff and the Deer Range Improvement Program coordinator in WD also assisted in this effort. This mesic conifer implementation process contains assessment, operations/logistics, and monitoring components.

The application of this process assumes: 1.) Operations Inventory (OI) stand classifications accurately reflect existing site conditions and not a desired future condition or management

option preferred by the stand examiner. 2.) We will accomplish and monitor the success of real, on the ground restoration of mesic conifers on 57,000 acres in the WUP. 3.) This phase of the process development focuses on site level variables and, when available, landscape level information may be used to help guide decisions.

Forestry and Wildlife field personnel within the individual FMUs will evaluate opportunities for enhancement or expansion of mesic conifers on a site-specific basis. This MC implementation process or MC action plan is for WD and FMFMD personnel including: wildlife biologists, technicians, foresters, timber management specialists, planners at all levels, contractors, private lands specialists (Landowner Incentive Program (LIP), and the UP Deer Range Improvement Program (DRIP) Coordinator. It is intended to be a straight forward, applied guide for people doing field evaluations, conducting OI and mesic conifer restoration and continuing through silvicultural practices, planting, follow up, monitoring, and feedback (adaptive management). It may also provide a useful model for MC restoration in the Eastern UP or northern Lower Michigan.

IMPLEMENTATION PROCESS

Mesic Conifer Site Assessment

The MCG set priorities for each FMU and overall acreage objectives for each species. And WUP Forest and Wildlife field personnel are charged with selecting sites for mesic conifer restoration or enhancement. The following describes a process for or an approach to selecting sites for MC restoration/enhancement and highlights variables and criteria to look for to optimize success. Although individual field personnel may approach mesic conifer site selection differently, there are basic questions that will need to be answered and common sources of information that are or will be available to assist.

Therefore, at both the WUP and FMU levels, key questions are:

1. Where do mesic conifers occur, including which species are where?
2. Where don't mesic conifers occur?
3. Where do we want mesic conifers to be? In addition,
4. Which habitats are suitable for mesic conifers and, if suitable,
5. Which sites are deficient in mesic conifers?

There are many resources and tools to assist in answering these questions. Digital mapping and geographic information systems (GIS) technology has transformed natural resources management. Natural resource managers can now discern ecological patterns at multiple scales: the coverage of mesic conifers across and within the Great Lakes region, Michigan, the Upper Peninsula, Western UP, state lands within the WUP, state forest compartments and so on. Resource managers can also analyze and monitor habitat changes by overlaying different data layers and attributes. The change in mesic conifer acreages reported in the WUP Interim Mesic Conifer Management Guidelines were in part derived at by comparing current to past vegetation coverage (See Discussion on GIS applications below and the Interim Mesic Conifer Guidelines in Appendix A). Habitats suitable for mesic conifer restoration can be discerned using similar comparisons.

The MCG (Appendix A) states that increasing the MC component is expected to increase the number of individuals of conifer associated bird species. And over time reduce productivity of the summer deer range and expand areas potentially suitable for deer during winter, resulting in

a smaller deer herd dispersed over a larger wintering area (Doepker et al, 2001) in turn resulting in less browsing pressure in WUP forests. The eventual size, configuration, contiguousness and/or juxtaposition of restored habitats to existing or historical mesic conifer habitats and winter deer-yards on non-MDNR lands (public and private) may affect the success of these outcomes.

Furthermore, landforms within different sub-sub sections defined by Albert (1995) and land-type associations as defined by the US Forest Service, reflect the landscape patterns of northern hardwoods and mesic conifers, influencing where opportunities for mesic conifer restoration may occur. For example the orientation and size of the drumlin fields in Menominee and Delta Counties provide opportunities for increasing mesic conifer that contrast with the bedrock knobs and rocky ground moraines of the Michigamme Highland in Marquette County. Also some potential mesic conifer sites may enhance proposed or existing MDNR old growth/biodiversity stewardship areas, natural areas or sites selected for mesic conifer restoration or conservation under programs such as the MDNR, WUP LIP and DRIP.

Our team has a collective interest in the landscape level hypotheses and opportunities discussed above. For efficiency we must leave the WUP mesic conifer landscape level analyses to future efforts within the MDNR WUP Management Unit. We recommend to the WUP Eco-team that a landscape level analysis receive high priority consideration. The MDNR Red Pine Project (Bielecki et al 2003) is one example of a landscape level approach to forest management. For those interested additional case studies from the western US may be found in Conserving Forest Biodiversity by Lindemayer and Franklin, 2002. The success of the WUP MC project in increasing tree species diversity and structural diversity within the northern hardwood community depends on the successes at the stand level. The process that follows focuses on actions for optimizing the potential for successful mesic conifer restoration and enhancement at the compartment/stand level.

Variables For Consideration As MC Restoration Sites

Where we "want" MC to be is, in part, determined by where mesic conifers were both a century ago and more recently. At a gross scale (greater than or equal to a square mile) circa 1800 vegetation maps help determine the historic occurrence and extent of mesic confers across the WUP landscape, counties or state forest compartments. Circa 1800 vegetation maps are easily viewed and/or printed at the county scale from the Michigan Natural Features Inventory (MNFI) website at http://web4.msue.msu.edu/mnfi/ under the "data resources" tab. County soil surveys, historical publications and personal accounts may be available. MDNR forest compartment files, databases such as OI or direct observations can provide information on recent stand history and past cutting practices. Field examiners can directly observe the presence of old (~100+ years) mesic conifer stumps, tip-up mounds, or evidence of large dead and downed logs. Individual field experience, knowledge and understanding of each species ecological requirements will also be helpful.

Once the historic range and specific site suitability for MC has been determined, the potential for successfully restoring or enhancing MC can be evaluated. The presence of MC on or adjacent to the stand suggests for which species to manage, in addition to providing choices for management treatments. The presence of seed trees may suggest an opportunity to use natural regeneration methods. If there are no seed trees, seedlings may need to be planted. Mesic conifers and other site variables such as presence of herbaceous competition (Pennsylvania sedge - *Carex pensylvanica* mat, bracken fern – *Pteridium aquilinum*) and light levels can be directly observed during on-site assessments. The presence of raspberries (*Rubus* spp.) indicates sufficient light levels for successful mesic conifer seedling establishment (R. Doepker,

personal communication). Micro habitats (e. g. local perched water tables, north facing slopes and individual drainages) will offer opportunities for hemlock establishment. Aerial photos, digital-ortho quads, leaf on/leaf off infrared photography may also be used (refer to the discussion on GIS applications below). County level "change" maps comparing circa 1800 vegetation to 1978 land use cover type maps may also viewed at the MNFI web site cited above.

What plants are growing at a site is related to that site's suitability for MC. Coffman et al (1984) and Kotar et al (1988) classified habitat types across Northern Wisconsin and Michigan based on soils, landform, understory vegetation and possible successional pathways leading to a potential climax community. The potential climax community or equivalent habitat type is named from plant indicator species at the canopy, shrub and/or herbaceous layers. The habitat type is abbreviated by using the first one or two letters of the genus and/or scientific plant names. Each habitat type also has a corresponding common name. For example AOCa refers to the *Acer-Osmorihiza-Caulophylum* or sugar maple/sweet cicely-blue cohosh habitat type.

The six habitat types proposed for the WUP are summarized in Tables 1 & 2. Table 1 refers to sugar maple climax habitat types at the more mesic (moist) and rich end of the soil moisture and nutrient spectrum. Table 2 refers to the pine climax habitat types associated with dryer and poorer soils. Soils and habitat types are related to landform. As discussed above, landform affects the location, size and configuration opportunities for increasing mesic conifers. In general, the natural processes in the sugar maple types are smaller in scale and are driven by small patch dynamics (Albert 1995, Frelich 2002). Whereas, pine types are fire dependent ecosystems driven by more frequent, large scale events including wind (Albert 1995, Frelich 2002). Understanding the natural processes gives insights into possible management treatments such as soil scarification or prescribed fire.

A decision key (Table 3) was developed to complement both the above discussion and a mesic conifer opportunity matrix (Table 4). Sequential questions and their answers help guide site selection for mesic conifers. Table 4 helps to identify opportunities for mesic conifer species and management objectives most suitable to existing over-story vegetation and the most common upland habitat types proposed for the WUP. The habitat types, although not explicitly shown on the table, are arranged by soil moisture and nutrient level. The bottom left corner of Table 4 starts with the driest, nutrient poor habitat type PArV (*Pinus/Arbutus-Vaccinium*), moves up to dry-mesic, nutrient medium AVVb (*Acer/Vacinium-Vibernum*) and ends in the top left corner with mesic, nutrient rich to very rich AOCa. Using the "proposed" habitat types, is dependent on the development of the WUP habitat type guidebook and training of MDNR staff in habitat type identification during summer 2004. Habitat type maps are also expected to be available for the WUP. Mapped habitat types should always be verified through stand field examination.

Management Objectives And Guidelines Based On Habitat Type.

By using Table 4 we can identify some general trends for management decision making. For instance, white pine and red pine are the preferred mesic conifer species for the pine climax habitat types under existing oak, pine aspen and conifer dominated hardwood overstory

Table 1: Sugar maple climax habitat type summary for the Western Upper Peninsula, Michigan (based on Burger and Kotar. in prep)

Habitat Type	**ATM** *Acer-Tsuga/ Mainthemum*	**ATD** *Acer-Tsuga/ Dryopteris*	**AOCa** *Acer/ Osmorhiza-Caulophyllum*
Plant Association	Sugar Maple –Eastern Hemlock/ Wild lily-of-the-valley *Acer sacharum,-Tsuga canadensis/ Maianthemum canadense*	Sugar Maple – Eastern Hemlock/ Spinulose shield fern *Acer sacharum –Tsuga canadensis/ Dryopteris spinulosa*	Sugar Maple/ Sweet cicely-Blue cohosh *Acer saccharum/ Osmorhiza claytonia – Caulophyllum thalictroides*
Climax Association	Sugar Maple, Eastern Hemlock, Yellow Birch	Sugar Maple, Eastern Hemlock, Yellow Birch	Sugar Maple with Basswood, White Ash, Yellow Birch, Eastern Hemlock, Balsam Fir
Soil	Well to moderately well drained sandy loams, also loams, silt loams and loamy sands.	Well to moderately well drained sandy loams and silt loams	Well to moderately well drained silt loams and loams
Moisture	Dry Mesic to Mesic	Mesic	Mesic
Nutrient	Medium	Medium to Rich	Rich to Very Rich
Landform	On most landforms within its range, most common on moraines	Moraines (especially ground moraines) and loess deposits	Moraines (especially ground moraines) and loess deposits.
What was there? Circa 1800 Vegetation (Albert 1995)	Sugar Maple, Yellow Birch, Eastern Hemlock Forest (Northern hardwoods with White Pine – Eastern Hemlock) Eastern Hemlock stumps Evident	Sugar Maple, Eastern Hemlock and White Pine – Yellow Birch – (American Beech In Central UP Counties and Eastward) Eastern Hemlock Or White Pine stumps Evident	Sugar Maple, Yellow Birch, Eastern Hemlock Forest (Northern hardwoods with White Pine – Eastern Hemlock) Eastern Hemlock stumps evident
Natural Processes (Albert 1995, Frelich 2002**)**	Wind – Large Scale Infrequent to Rare Intense Blow-downs – Small Scale Individual Trees = Small canopy gaps Fire – Large Scale windfall potentially followed by fire Big Tree Senescence – Small canopy gaps – Large woody debris, individual logs		

Table 2: Pine climax habitat type summary for the Western Upper Peninsula, Michigan (based on Burger and Kotar. in prep)

Habitat Type	**PArV** *Pinus - Acer rubrum/ Vaccinium*	**PArVAa** *Pinus – Acer rubrum/ Vacinium – Aralia*	**AVVb** *Acer/ Vaccinium-Viburnum*
Plant Association	White Pine-Red Maple/ Blueberries *Pinus strobus – Acer rubrum/ Vaccinium angustifolium*	White Pine – Red Maple/ Blueberry – Wild Sarsparilla *Pinus strobus - Acer rubrum/ Vacinium angustifolium – Aralia nudicaulis*	Sugar Maple/ Blueberry – Maple-leaved viburnum *Acer saccharum/ Vaccinium angustifolium-Vibernum acerifolium*
Climax Association	White Pine, Red Maple, Red Oak, Balsam Fir, White Spruce	White Pine with any of Red Maple, Red Oak, Balsam Fir, White Spruce	Sugar Maple, Red Maple, Balsam Fir (Red Oak and White Pine depending on disturbance regime)
Soil	Excessively to somewhat excessively drained sands and loamy sands	Sands to loamy sands, somewhat to excessively drained	Well drained sandy loams and loamy sands
Moisture	Dry	Dry – Dry Mesic	Dry Mesic
Nutrient	Poor	Outwash with moraines and lake plains where water worked sands have accumulated.	Medium
Landform	Predominantly outwash, occasionally on moraines where water worked sands accumulated	Poor – Medium	End and recessional moraines and pitted outwash
What was there? Circa 1800 Vegetation (Albert 1995)	Red Pine and Jack Pine/Jack Pine- hardwood (Dry Northern Forest) Charred Red Pine stumps evident	Red/White/Jack Pine – Oak (Dry -Mesic Northern Forest) Eastern Hemlock, White or Red Pine stumps evident	White, Red. Jack Pine, Oak (Dry -Mesic Northern Forest) White Pine or Red Pine stumps evident
Natural Processes (Albert 1995, Frelich 2002**)**	Fire – Large Scale Intense stand replacing following wind-throw or crown fires every 120 – 300 years. – Small Scale More frequent (every few decades) low intensity surface fires – maintains mature pines Spot fires Wind – Large scale blowdowns Small scale individual trees canopy gaps		

Table 3: Mesic Conifer Opportunity Decision Key

1. Where did mesic conifers occur a century ago and/or more recently?
   1a. Has the site supported mesic conifers?
   No Low priority.
   1b. Yes Go to 2.

2. What is the potential for successfully restoring or enhancing mesic conifers at this site?
   2a. Do mesic conifers occur on or adjacent to the stand of interest?
   No Low or Medium priority - Go to 3.
   2b. Yes Go to 3

3. Which species are most suitable to this site? (Refer to Table 1.)
   3a. What is the habitat type?

   Pine Climax Types (PArV, ParVAa, AVVb) *Use Red or White Pine. - Go to 4*

   3b. Sugar Maple Climax Types (ATM, ATD, AOCa) Use White Pine or Hemlock. - Go to 4

4. Browsing Pressure?
   4a. Heavy browse?
   No Go to 6
   4b. Yes Go to 5

5. Existing overstory aspen or northern hardwood?
   5a. Yes Use Balsam Fir and White Spruce - Go to 6
   5b. No Low priority

6. What is the mesic conifer management objective? Refer to Table 1.
   6a. Is the existing overstory?

   Oak or Aspen? Convert to conifer or manage as an associate.

   6b. Pine? Maintain conifer.
   6c. Northern Hardwood? Go to 7

7. What is the condition of the hardwood? (Refer to Table 1.)
   7a. Is the northern hardwood quality potential?

   Poor? Maintain or convert to conifer.

   7b. Good? Maintain hardwood, maintain or enhance conifer, or manage for mixed stands.

Table 4: Management opportunity matrix for mesic conifers on MDNR managed forests in the Western Upper Peninsula, Michigan.

		Existing Overstory						
	Habitat Type ?	***Oak*** *Convert to conifer or manage as associate*	***Pine*** *Maintain conifer*	***Aspen*** *Convert to conifer or manage as associate.*	***N. hardwood BA > Conifer*** *NH quality potential poor, convert to conifer*	***N. hardwood BA > Conifer*** *NH quality potential good, maintain hardwood & maintain or enhance conifer*	***Conifer BA > N. hardwood,*** *NH quality potential poor, maintain conifer*	***Conifer BA > N. Hardwood*** *NH quality potential good, manage for mixed stands*
Sugar Maple Climax Habitat Types	**AOCa**			WP Hemlock	WP Hemlock	WP Hemlock	WP Hemlock	WP Hemlock
	ATD			WP Hemlock	WP Hemlock	WP Hemlock	WP Hemlock	WP Hemlock
	ATM	Oak WP	RP, WP	WP (BF, WS)	WP Hemlock (BF, WS)	WP Hemlock (BF, WS)	WP Hemlock (BF, WS)	WP Hemlock (BF, WS)
Pine Climax Habitat Types	**AVVb**	Oak WP	RP, WP	WP, RP (BF, WS)	WP, RP (BF, WS)		WP, RP (BF, WS)	
	PArVAa	Oak RP WP	RP, WP	RP, WP (BF, WS)	RP, WP (BF, WS)		RP, WP (BF, WS)	
	PArV	Oak JP RP	JP, RP	JP, RP	JP, RP			

The purpose of this matrix is to establish management objectives for mesic conifer development with consideration given to site quality which implies tree quality potential. The risk of browsing on the tree seedlings must also be weighed in the decision process. Where the probability of browsing is high the species in parenthesis (BF, WS) should be favored. This matrix covers the proposed habitat types for the most common upland stand cover types in the Western UP. Where habitat type information is incomplete a general guideline is to favor white pine on drier sites and hemlock on more mesic sites.

Key to abbreviations

BA		basal area
BF		balsam fir *Abies basamea*,
Hemlock		eastern hemlock *Tsuga canadansis*
JP		jack pine *Pinus banksiana*
N hardwood		northern hardwood community
Oak		red oak *Quercus rubra* and northern pin oak *Q. elipsoidalis*
RP		red pine *Pinus banksiana*
SM		sugar maple *Acer sacharum*
WP		white pine *Pinus strobes*
WS		white spruce *Picea glauca*
YB		yellow birch *Betula alleghaniensis*

conditions. Whereas, white pine and eastern hemlock are preferred for sugar maple climax habitat types under aspen and all hardwoods regardless of conifer dominance. While balsam fir and white spruce are mesic conifers of choice when browsing pressure will not result in a successful restoration or enhancement with other species. Jack pine and or oak are noted as alternatives to mesic conifers under an overstory of oak, pine, aspen and hardwood where the hardwood site potential is poor. However, oak and jack pine do not count towards meeting the mesic conifer guideline objectives. Management objectives and guidelines for each habitat type are discussed in more detail in the following paragraphs.

Sugar Maple Climax Habitat Types

ATM *Acer-Tsuga/Mainthemum*
ATD *Acer-Tsuga/Dryopteris*
AOCa *Acer/Osmorhiza-Caulophyllum*

The sugar maple habitat types represent the typical northern hardwood dominated sites in the WUP. Mesic conifer management guidelines for the three habitat types are similar, therefore they are discussed as a group. The sugar maple habitat types represent a moisture-nutrient gradient with ATM on the dry-mesic/medium rich end and AOCa on the mesic/very rich end of the hardwood site habitat types (Table 1). These sites are well suited to supporting conifers in association with hardwoods. In the early 1800's these sites supported forests of sugar maple and yellow birch with various complexes of white pine and hemlock (Table 1). Today much of the conifer component is missing as a result of past management, but remnants can be managed to enrich the existing conifer component or reintroduce it. There is also a high degree of compatibility between management objectives that feature high value hardwoods and increasing the conifer associates in the stand.

First to determine for sugar maple habitat type sites is whether the ultimate site objective is to focus primarily on hardwood with conifers as associates or it is to feature conifers with hardwoods as the associate. In either case, hardwoods will continue to be major components of the stands but the emphasis on conifers will be different depending on the answer to the question. In both cases where the hardwood site potential is poor the management objective is to convert to conifers regardless of the ratio of hardwood to conifer (Table 4). In this case where conifers are to be the primary feature of the stand, an even aged hardwood management system like a shelterwood should be used to create the maximum opportunity for white pine and hemlock to establish and grow.

In a hardwood overstory, where the hardwood basal area is greater than the conifer component and the site potential is good (Table 4), the potential objectives may be to maintain or develop mesic conifer as an associate from 30% – 50% basal area and favor the retention of long-lived species (e. g. white pine and eastern hemlock). Where the conifer basal area is greater than the northern hardwoods with good hardwood site potential then the objective is to manage for mixed stands (Table 4). Here the conifer component should be managed from 40% – 60% of the total basal area, maintaining hardwood as a co-dominant associate and favoring the retention of long-lived species such as white pine, eastern hemlock, yellow birch and sugar maple. Selective cutting should be employed to develop the quality and value of the hardwoods while at the same time the conifer component can be enriched through snow free harvesting, creating surface disturbance and germination opportunities for pine and hemlock. If necessary, under-planting can be employed to reintroduce white pine or eastern hemlock into the stand but this approach should be limited to those sites which cannot be enriched by a natural regeneration approach.

Under-planting guidelines as discussed for the pine climax habitat types below should be followed here as well.

Pine Climax Habitat Types

In each of the three pine climax habitat types mesic conifer management objectives for existing overstory of either oak or aspen are to convert to conifer or manage as an associate (Table 4). If the overstory is pine dominated the mesic conifer management objective is to maintain the pine (Table 4).

Acer/Vaccinium-Viburnum (AVVb): The AVVb habitat type commonly supports good quality aspen, white birch, red oak and red maple stands. Conifer components can be expanded in these stands where existing white pine, red pine, white spruce or balsam fir are present. Stands composed of any of the deciduous species mentioned will naturally succeed to the conifer species if they are present. These kinds of sites present the land manager with natural regeneration opportunities for gradual conifer enrichment as well as rapid conifer conversion (Table 4). Increasing the conifer component gradually over several rotations of hardwood is highly compatible where the management objectives are for oak, aspen or birch. In those cases, clear-cuts leaving advanced conifer regeneration when the hardwoods are harvested and scheduling harvest for snow free condition will provide germination opportunities for the conifer species. Prescribed fire may also be a management tool. If more rapid conversion to conifers is desired this can be accomplished through shelterwood cutting and under-planting.

Under-planting decisions should be based on the results of seedling surveys. As a very general rule, stocking counts of less than 300 per acre would indicate a need to plant additional seedlings to achieve the desired conifer objectives. Planting decisions should also consider the probability of being browsed by deer and modified accordingly.

Pinus-Acer rubrum/Vaccinium-Aralia (PArVAa): The PArVAa sites can be successfully managed for red pine or white pine using natural regeneration methods or conventional planting methods described above. Natural regeneration methods for red pine can be accomplished using very open shelterwood cuts (residual basal area of 30 ft^2) or patches of seed trees interspersed between openings of 70 – 80 feet in diameter. These can be followed by scarification if necessary. The unpredictable, infrequent nature of red pine seed crops makes this approach difficult but effective if the timing is good. In mixed red and white pine stands shelterwood harvests followed by scarification usually provide adequate regeneration of white pine. Competing deciduous vegetation must be controlled for early survival and growth. In aspen or northern hardwood stands where there is well established advanced reproduction of white pine the stand can be converted to pine by carefully removing the overstory and releasing the pine. Natural regeneration using prescribed fire will favor both oak and pine regeneration and reduce competition from ennsylvania sedge. In areas where deer browsing precludes the possibility of successful pine regeneration balsam fir or white spruce can be used following similar treatments.

Measure of Success

After 1 – 2 years, 700 seedlings/acre
After 5 years, 500 saplings/acre free to grow
After 50 years, 200 – 250 trees/acre
175 years basal area fully stocked

Pinus-Acer rubrum/Vaccinium (PArV): Jack pine and red pine are the preferred conifer species on the PArV habitat type sites. Jack pine can be established using the furrow, seed or furrow plant method. Red pine should be established using the furrow, plant method. Competing deciduous vegetation should be controlled with the use of herbicide or fire if appropriate. Natural regeneration using prescribed fire will favor both oak and pine regeneration and reduce competition from Pennsylvania sedge. The conifer component in aspen stands can be managed using species selection (mark to cut/mark to leave). Regeneration efforts should be monitored for at least the first three years to assure adequate survival and competition free growing conditions.

Measure of Success

After 1 – 2 years, 700 seedlings/acre
After 5 years, 500 saplings/acre free to grow
After 50 years, 200 – 250 trees/acre
175 years basal area fully stocked

Assessment Tools

Concept of Geographic Information System Use in Mesic Conifer Decision Making

The development of a Multi-Objective/Multi-Criteria based Decision Support System (DSS), that will be easily utilized by decision makers at all levels, is critical to the success of this project. The DSS will be intuitive and universal, providing resource managers with a set of tools to efficiently assess and implement mesic conifer management on state forest lands, at the stand and landscape level, using forest habitat type classification systems developed for the WUP of Michigan.

Habitat maps will be created by Burger and Kotar (2003). These maps will be produced by superimposing high resolution soil type maps for western Upper Michigan, produced by the USDA Natural Resources Conservation Service (SSURGO Database), with forest habitat type classes defined by Kotar and Coffman (1984). The resulting forest habitat type maps will be used to identify the forest habitat class (or range of classes) that occur on particular soil types.

A land cover map (circa. 1800) generated from the General Land Office (GLO) surveyors' notes by Michigan Natural Features Inventory, will be overlaid with Burger and Kotar's original forest habitat type plots within a Geographic Information System (GIS) to examine the correspondence between the historical extent of forest types and land suitability classes. By comparing GLO forest community maps and the forest habitat type maps described above, the extents of regions suitable for mesic conifer growth will be identified for this project. Inclusion of digitized State forest compartment maps in the GIS will make possible the evaluation of past, current, and desired conditions specific to state-owned lands.

The Integrated Forest Monitoring and Prescription system (IFMAP) is scheduled to roll out in 2004 and 2005. IFMAP: 1.) will use a State-wide land cover map based on classification of Landsat TM satellite imagery (collected during periods of "leaf-on" and "leaf-off" for deciduous vegetation) and will integrate it with the federal Forest Inventory and Analysis (FIA) system to produce a State-wide estimate of forest resources; 2.) will use DNR lands multi-resource inventory, based on interpretation of high-resolution imagery and a redesigned DNR field

inventory, to produce an estimate of State Forest resources; and 3.) will use a custom client/server GIS application for supporting collection, storage, access, and analysis of inventory data based on ESRI's® Arc 8™ and ArcSDE™ software. Use of "leaf-off" thermal imagery associated with IFMAP (in correlation with Kotar and Burger's original forest habitat type plots) will allow land managers to better identify cover types suitable for increasing existing mesic conifer.

The guidelines and tools developed for this project will be fully incorporated with IFMAP. Until IFMAP is fully developed, the DSS will be available as a web-based application to land managers. Upon IFMAP roll out, the DSS could remain web-based to facilitate communication with interest groups and the public that are unable to access the DNR computer network or IFMAP.

Because the DSS provides multiple perspectives that are often difficult to determine in the field, it will facilitate multi-scale decision making. The spatial dimensions associated with the DSS will help resource managers evaluate past, present, and future forest/non-forest conditions and identify suitable mesic conifer management alternatives to accomplish various stand, compartment, or landscape ecosystem goals on state forest lands. However, even though the DSS will provide a wide range of information for resource managers, it is not intended to substitute for field work, but rather compliment it.

Resource Needs:

To accomplish the concept described above (over the short term), either ArcGIS™ or ArcView 3.x™ with Spatial Analyst™ extension will be required for the initial evaluation of potential mesic conifer management. Each of these products is produced by ESRI®.

Development of a web-based Decision Support System will require ArcIMS™, also developed by ESRI®. With ArcIMS™, a web application can be created to allow end users to pan, zoom, and identify features from GIS datasets within interactive maps.

Final release and utilization of this project will require the IFMAP system being developed for the Michigan Department of Natural Resources and scheduled for roll-out in 2004 and 2005.

The MIWILD database (incorporated with IFMAP) will provide a means of assessing past conditions, examining current conditions, and evaluating the potential for various wildlife habitats.

Operations/Logistics

Logistical Procedure For Mesic Conifer Planting

FTP Development And Approval.

Preparation Timeframe**:**

1. If stands exist that meet the criteria for planting sites, they will be identified in the wildlife comments section, of the OI database as **'mesic conifer project' stand recommended as**

mesic conifer planting site, prior to the compartment review. FTPs will be developed after sites have received approval through the compartment review process.

2. If the stand is scheduled for a commercial treatment before planting, the timber sale completion report will be the trigger to activate the FTP. The completion report must be checked against the OI for planting.

Approval Path: FTPs will follow the same approval path as all other FTPs. Out-of-entry Year FTPs are discouraged.

Site Delineation - GPS: Delineation of the area to be planted should be delineated using GPS. This data should be incorporated into the monitoring database and maps of the area attached to the FTP completion report.

Tracking/ Location: This will be accomplished through the OI database under wildlife comments and each stand will have the unique identifier **"mesic conifer project"- stand recommended as mesic conifer planting site.** Species planted and objectives will be added in the wildlife comments field. Cultivation codes will be added during OI. If natural regeneration of mesic conifers is the objective and there is not a FTP for planting, OI comments should state **"monitoring will be needed after timber sale"**.

Completion Reports: Each Year after planting operations are completed, Area Biologist/Technicians will develop completion reports for planting operations by end of the fiscal year, September 30th. Copies of these reports should be sent to the DRIP coordinator and WUP MC Project Coordinator.

Contract For Growing Out Trees:

Coordination Throughout WUP - The DRIP Coordinator will generate one WIP grant to secure funds for both seedling growing and/or purchase and tree planting by contractors. In addition, the DRIP Coordinator will contract one or more nurseries to grow the appropriate quantity and quality of desired conifers species to supply the entire WUP planting program, according to purchasing protocol. WUP Biologists and Technicians will determine the species and quantities of each that should be grown or purchased for upcoming seasons.

Nurseries Currently Available To Contract

Toumy Nursery
Tom Nolta Nursery:
Itasca Nursery:
Chippewa Farms Nursery:

Contracting For Tree Planting.

Coordination Throughout WUP: One tree planting contract for the WUP will be developed by the WUP MC Project Coordinator according to purchasing protocol.

Scheduling Considerations Of Planting Activities: The WUP MC Project Coordinator will coordinate the planting activities between the nursery supplying the trees, the planting

contractor and the Area Biologists and Technicians within the WUPMU. This should start by mid-May, to avoid desiccation of newly planted seedlings.

On-site supervision of planting operation-Supervision of planting crews will by done by either the Area Biologist or Wildlife Technician that developed the FTP, with the assistance of the WUP MC Project Coordinator, as needed. If the area was not delineated (GPSed or flagged) prior to generation of the FTP, this will need to be done prior to the planting crew's arrival.

Past Contractors:

Tom Nolta Tree Planting Service
DNR short term workers

Scheduling, Delivery And Handling Of Seedlings.

Pickup and Storage Options: WUP Planting crew may be contracted to pick up trees and provide cold storage as part of their contract. If this is not an option, each Area's Biologist and/or Technician may need to secure trailers to transport and coolers for seedling storage during planting operations. This will be coordinated between Area Biologist/Technicians and wildlife technician, M. Joseph. Seedlings can be stored in coolers for a recommended period of time (depends on when trees were bagged at the nursery) after delivery from nursery.

Handling of seedlings: Transportation of seedlings from coolers to planting sites may need to be done daily by Area Biologist/Technicians during the planting operation, if not incorporated into the tree planter's contract.

Monitoring Protocol: Each planting site will be delineated using GPS equipment and coordinates entered into monitoring/regeneration check database. Details of monitoring procedure are discussed in monitoring section of this report.

Contact Names and Numbers WUP Management Units:

Baraga: 906-353-6651
Rob Aho
Brad Johnson

Crystal Falls: 906-875-6622
Doug Wagner
Monica Joseph

Norway: 906-563-9077
Mark McKay

Gwinn: 906-346-4442
Mike Koss
Ben Travis

Escanaba: 906-786-2351
Craig Albright

MEASURING SUCCESS

Monitoring and Adaptive Management

In December 1987 MNDR Fisheries, Forest Management and Wildlife Divisions embarked on a Joint Venture to insure the MDNR meets it mission, the conservation, protection, management, use and enjoyment of the State's natural resources for current and future generations, by embracing the concepts of ecosystem management. As part of an overall strategy to move forward together the divisions also agreed to implement the principles of adaptive management "by which multiple hypotheses are continuously tested to develop new understanding of ecosystem principles, feedback is incorporated into future planning efforts and course adjustments are incorporated in a timely fashion". Most recently (2003), the Statewide Council charged the WUP Eco-unit team to utilize the Ecological Society of America's (ESA) elements of ecosystem management for planning and managing Michigan's natural resources. The eighth ecosystem management element, "adaptability and accountability" states, "we recognize current knowledge and paradigms of ecosystem function are provisional, incomplete and subject to change. And management approaches are hypotheses to be tested by research and monitoring programs." In other words, monitoring is necessary for testing our assumptions about, providing feedback on and prompting changes to natural resources management practices.

The Mesic Conifer Implementation Process addresses two monitoring objectives identified in the Interim MCG (Appendix A). The first objective is to monitor changes from the existing forest types for a 20-year period. The second is to monitor the results of silvicultural prescriptions. A third objective - to qualitatively assess the impact of deer browsing on tree regeneration and recruitment - is addressed peripherally in this document and may require additional work and resources. A 39 step operational and monitoring plan for implementing the Interim WUP Mesic Conifer Guidelines is provided (Table 5). Selecting sites and implementing management by applying steps 1 -18 is pre-requisite for successfully accomplishing steps 19 – 39 to monitor and adapt management for the mesic conifer project (Table 5).

These monitoring objectives fall primarily into two categories – "implementation monitoring" and "effectiveness monitoring" – and somewhat into a third category of "validation monitoring" as defined by The Nature Conservancy (2001). Each category is described below.

1. Implementation Monitoring
   i. The goal - To track implementation status or determine if WUP mesic conifer management treatments were accomplished;
   ii. The question – "Did we do what we said we were going to do?" Or "Did we treat where, for what, and how we said we were going to treat?"
   iii. Example: To reach a 57,000 acre target for mesic conifer restoration over 20 years, each year a minimum of 2,850 acres of state forest land in the WUP will be treated for mesic conifer restoration - specifically a minimum of 600 acres hemlock, 700 acres balsam fir–white spruce, 500 acres natural red pine and 1,050 acres white pine per year.
2. Effectiveness Monitoring
   i. The goal - To determine if WUP mesic conifer management has achieved the stated objectives.
   ii. The question – "Is it working or did it work?"
   iii. Example - Are the management treatments (silvicultural prescriptions) working to restore mesic conifers to the WUP northern hardwoods? Are mesic conifers:
      - Being recruited into (the canopy of) the hardwood dominated forest, and
      - Expanding around existing stands?

Table 5: Mesic Conifer Implementation Process - Operational and Monitoring Steps

Key: MC = Mesic Conifer
FMFMD = Forest, Mineral, Fire Management Division
WD = Wildlife Division
Local = Area Wildlife Biologists, Foresters, Technicians
Ecoregion = Western Upper Peninsula Supervisors, Planner, Deer Range Improvement Program (DRIP) Coordinator, Specialists
State = Program Managers and Specialists
OI = Operations Inventory

Step #	Action	Who	Management Level	When
	SELECT MC SITES			
1.	Select potential sites (Refer to the MC Site Selection Section for details.)	FMFMD or WD	Local	During OI
2.	Recommend stands for inclusion in the mesic conifer project	FMFMD or WD	Local	During OI
3.	Approve MC projects.	FMFMD and WD	Local Ecoregion, State	Compartment Review
4.	Add cultivation codes to the OI database.	FMFMD or WD	Local	During OI
5.	Add a unique identifier into the OI database under the OI Wildlife Comments. a. **"**mesic conifer project"- stand recommended as mesic conifer planting or scarification site" GO TO STEP 6 or	FMFMD or WD	Local	Compartment Review or shortly after
	b. "mesic conifer project" – stand recommended for natural regeneration - monitoring will be needed after timber sale" GO TO STEP 19	FMFMD or WD	Local	Compartment Review or shortly after
	IMPLEMENT MANAGEMENT			
6.	Maintain a filing system and database with tasks and dates to track implementation progress.	WD and FMFMD	Local	Ongoing
7.	Secure funding – submit Work Item Proposals (WIPs) for seedlings, treatments and monitoring.	WD	Local Ecoregion State	Annually by May 1
8.	Develop Forest Treatment Proposals (FTPs) for planting, scarification or prescribed burning.	WD and FMFMD	Local	Shortly or 3 weeks after Compartment Review

	Table 5 Continued			
9.	Prepare timber sale and communicate anticipated schedule for timber sale completion to WD. (A 2 – 3 year projection by species is needed to order seedlings, secure equipment and prepare contracts. Or a set number of seedlings may be ordered every year.)	FMFMD	Local	Each year.
10.	Execute timber sale and treat stand commercially.	FMFMD and Contractor	Local	Within five years of Compartment Review
11.	Prepare the Timber Sale Completion Report (TSCR)	FMFMD	Local	Immediately after the timber sale
12.	Check TCSR against OI for mesic conifer planting or regeneration.	FMFMD	Local	Immediately after TSCR is completed
13.	Send copies of TSCR to Wildlife Technician or Biologist and the UP DRIP Coordinator.	FMFMD	Local	Immediately
14.	Implement/Activate a. Planting FTP (see logistics section - order trees - plant etc.) b. Scarification FTP	WD	Local	Time dependent - due to site condition.
15.	GPS treatment boundaries	WD	Local	Shortly before forest treatment.
16.	Prepare MC FTP (Planting or Scarification) Completion Reports including digital map, shape file and/or GPS coordinates and	WD	Local	Annually by September 30
17.	Update Wildlife Comments in OI reflect FTP completion, objectives and species planted.	WD	Local	Annually by September 30
18.	Send MC FTP completion reports to the MC Project Coordinator and the DRIP Coordinator	WD	Local	Annually by September 30
	MONITOR **Management Effectiveness** Determine if WUP MC management has achieved the stated objectives. Are the management treatments working to restore MC to the WUP northern hardwoods? GO TO STEP 25 **Management Implementation** Track implementation status to determine if WUP MC management treatments were accomplished. Did we treat where, for what, and how we said we were going to treat? GO TO STEP 19			
19.	Query OI database by management unit, proposed mesic conifer project, treatment, species, acres, and location.	WD	Local	Annually by February 1.

	Table 5 Continued			
20.	Compile data from FTC Reports by management unit, species, treatment, acres, and location.	WD	Local	Annually by February 1.
21.	Adapt to “regen” or develop and populate a spatial (GIS) relational database for proposed and completed treatments. FMFMD uses "regen” a forest regeneration database - a GIS that contains information concerning the location, and stocking of forest regeneration plots. Queries can be made spatially or through the access database it contains.	WD	Local	Annually by February 1.
22.	Analyze proposed treatments against completed treatments to compare actual progress against stated goals for each management unit.	WD	Local	Annually by February 1.
23.	Send data and analyses to assigned WD mesic conifer coordinator, WUP Planner and/or DRIP Coordinator.	WD	Local	February 1.
24.	Compare actual progress against stated goals for the WUP and to compile a WUP progress report. GO TO STEP 37	WD	Ecoregion	Every two years.
	MONITOR **<u>Management Effectiveness</u>** Determine if WUP mesic conifer management has achieved the stated objectives. Are the management treatments (silvicultural prescriptions) working to restore mesic conifers to the WUP northern hardwoods?			
	With OI			
25.	Compile OI cover type and understory data at the forest compartment and FMU levels and send to the WD MC Project Coordinator, WUP Planner and/or DRIP Coordinator.	WD	Local	Annually
26.	Combine and analyze OI results at the Ecoregion level. GO TO STEP 35	WD	Ecoregion	Annually by September 1
	Field Monitoring (Appendix B)			
27.	Secure funding for monitoring contracts – prepare WIPs for following year	WD	Local Ecoregion	Annually by May 1
28.	Provide maps and monitoring protocol to contractors.	WD	Local Ecoregion?	Annually by May 1
29.	Sample sites.	Contractors	Local	Annually mid May to August
30.	Provide sampling data to local WD and Timber Management Specialists	Contractors	Local	Annually by September 1

	Table 5 Continued			
31.	Enter data into the GIS/relational database (See Step 20).	WD	Local	Annually by mid October 1
32.	Compile and analyze seedling survivorship data averaged for each site and using the "regen" program. Send report to WD MC Project Coordinator, WUP Planner and/or DRIP Coordinator. GO TO STEP 37.	WD	Local	Annually by November 1
33.	Compile and analyze data for each species, treatment and attributes, forest compartment, FMU and WUP levels.	WD	Ecoregion	Annually by February 1.
34.	Use OI analysis and compare to field monitoring data Analysis.	WD	Ecoregion	Annually by February 1.
35.	Compare actual progress against stated goals for the WUP. GO TO STEP 37	WD	Ecoregion	Annually by February 1
36.	Look for successes and failures between different treatments for each species in different locations etc. from year to year. GO TO STEP 39	WD	Local Ecoregion	Annually by February 1
	ADAPT MANAGEMENT.			
37.	If the trajectory for meeting MC treatment acreage goals by species, management unit and WUP falls below the annual goal level – increase treatment proposals accordingly. REPEAT STEPS STARTING AT 1.	WD and FMFMD	Ecoregion	Every two years.
38.	If seedling density (survivorship) drops below 700/acre in the first or second year, decide to re-treat. REPEAT STEPS 7, 8, 14 – 37 Stay – CONTINUE MONITORING STEPS 27 - 36, or abandon – ENTER INTO MONITORING DATABASE AS A FAILURE.	WD	Local	Annually
39.	Modify the implementation process accordingly, chose the successful treatments and implement them more often - if insights into the success of different treatments by species and site attributes begin to emerge.	WD	Local Ecoregion	Annually or as soon as relatively reliable trends or patterns emerge from the monitoring data.

3. Validation Monitoring
   i. The goal is to determine if assumptions and models used in developing a management plan are correct.
   ii. Questions - form the basis for a research study.
   iii. Example - Which silvicultural treatments work compared to each other and between different snow fall zones and differing browse levels?

To recap, the mesic conifer site approval (Table 5: Steps 1 – 5) follows the compartment review process established for all state forests. Each year ten percent of state forest lands are field inventoried and scheduled to be treated (managed) for the following year. Wildlife and forestry resource managers select sites for potential mesic conifer treatment during the inventory period. After which they agree on the proposed treatments. The public may comment on the joint WD and FMFMD management proposal via an annual open house and subsequent compartment review meeting. Mesic conifer projects are approved at the compartment review and entered into the OI database.

When planting, scarification, or fire is prescribed, wildlife and forestry resource managers initiate mesic conifer management by preparing forest treatment proposals. Refer to Table 5: Steps 6 - 14 and the Operations/Logistics section. Foresters prepare a Timber Sale Completion Report (TSCR) after the timber is sold and the stand is treated commercially. Between the time of the timber sale and harvest completion, it is essential that excellent communication and planning occur among WD and FMFMD staff to allow for time to obtain tree seedlings and prepare planting and monitoring contracts. Wildlife resource managers begin tree planting or scarification after receiving the TSCR. Global Positioning System (GPS) technologies are used, shortly before planting or scarifying the site, to delineate stand treatment boundaries or for monitoring natural regeneration shortly after timber sale completion. Wildlife managers prepare and send a mesic conifer treatment completion report to the mesic conifer project manager and the WD DRIP coordinator.

Monitoring Implementation: (Table 5: Steps 19 -24)

The status of mesic conifer treatment proposals must be tracked over time if to monitor the effectiveness of mesic conifer restoration treatments. Therefore we need to know what, if, when and where proposed treatments took place. WUP wildlife biologists, technicians and foresters in each management unit will need to establish acreage goals for each species based on priorities established in the WUP Interim Mesic Conifer Guidelines. For example, if 600 acres are to be treated for hemlock restoration each year, (See example 1.iii. above) the majority of the acres will fall into the Baraga and Gwinn Management Units for which hemlock is the first priority. An example breakdown for hemlock treatment might be 250 acres each for Baraga and Gwinn, 85 acres for Crystal Falls and 15 acres for Escanaba for a total of 600 acres per year. Annual acreage will depend on the amount of suitable MC habitat available for treatment in the given year of entry.

Analyzing Monitoring Implementation Data: (Table 5: Steps 22 -24)

To track the implementation status for MC management by management unit, the respective manager will query the OI database by “proposed mesic management project”, species, treatment, acres and location. Similarly, the same data will be compiled from mesic conifer project completion reports. Ideally, both data sets (OI and completion reports) can be entered into a relational database (ACCESS) by year and linked to a spatial (GIS) database developed

for proposed and treated mesic conifer sites. FMFMD's "regen" database may be suitable for this purpose. The GIS layers will be developed initially from the compartment maps and subsequently from the GPS coordinates as treatments are completed. Management implementation (treatment) progress can be compared against the goals for each management unit. Each MU will send a progress report to the mesic conifer project manager to compile a WUP Mesic Conifer Implementation monitoring report. The report will show if the rate of actual treatment completions are on an adequate trajectory to meet the 20 year mesic conifer project acreage goals. Local management units can adapt the rate of mesic conifer management implementation as needed based on both local and WUP goals.

Monitoring Management Effectiveness: (Table 5: Steps 25 – 36)

Presented below are methods for determining the effectiveness of silvicultural treatments (prescriptions) in meeting the management objective to restore mesic conifers to the WUP northern hardwoods on 57,000 acres over 20 years.

One method for monitoring effectiveness is to monitor changes from the existing forest types. According to the Interim WUP Mesic Conifer Guidelines (Appendix A) this will be accomplished through the Operations Inventory (OI) and Compartment Review process. The MC Guidelines state that *changes from the existing forest cover types, indicating a change from hardwood to conifers and vice versa, will be recorded and compiled to provide information on changes over the 20-year period. IFMAP procedures should not alter this process if OI data is used as the base for comparison.*

Using the OI database to track changes from existing cover types at the individual stand level may not be practical due to the general functions of the OI database. Some of these issues are as follows.

1. Stand boundaries and numbers can change completely from one compartment review cycle to another making it difficult to match earlier treatments to new stand boundaries.
2. Management for species other than conifers may remain the management objective in specific stands. However, mesic conifer enhancement may also be a secondary objective for these stands. Therefore, the complete management objective for the stands may not be clearly identified in the database.
3. If mesic conifer seedlings do not reach 4 ½ feet in height after ten years, they will not be coded by the stand examiner for inclusion in the OI canopy or understory fields. Therefore if mesic conifers were in sufficient numbers to be recorded in OI ten years after a forest treatment, we may be able to claim potential success within that stand (depending on the stocking level). However, if the OI record does not show mesic conifer species presence in the understory or canopy level, we can NOT say for sure the treatment was NOT successful.
4. Since stands are entered on a ten year cycle, any stand treated in year 11 or after will not be captured in OI until year 21 which is a year after our 20 year management period.
5. Data variability is high due to inconsistencies in data collection methods between surveyors.

However, the OI database can be used as tool to track overall changes in vegetation cover type over time. Assuming compartment boundaries do not change significantly over time, cover type changes on state land can be tracked annually at multiple and consecutively larger scales, i.e., compartment, forest management unit, and WUP. OI data can not be directly correlated with specific mesic conifer management treatments due to the problems inherent above and the potential for cover types to change independent of mesic conifer treatment. The OI database for FMU and Compartments will need to be queried for cover type and understory data annually.

These data should be compiled and analyzed at the local unit level and sent to the WUP mesic conifer project coordinator for compilation and analysis at the WUP level.

The OI cover type data analyses may be come more useful when combined with direct field observations. A protocol to monitor the success of mesic conifer regeneration by planting, scarification or other natural regeneration methods was developed by Kim Herman, WD and James Ferris, FMFMD (Appendix B.) The FMFMD 2001 Forest regeneration survey manual by Roger Mech and Jim Bielecki with The Nature Conservancy 2002 Vegetation monitoring in a management context workshop manual were consulted as part of this effort. Regeneration data will be used to determine where MC stocking is adequate and where and when additional treatment/prescription may be necessary for any given treatment site.

The field monitoring effort (Appendix B) is designed for short term and long term purposes. Preferably, a pre-treatment baseline can be established after which on site monitoring will continue 1, 2, 5, 10 and 20 years after treatment. Circular 1/100th acre plots will be sampled along regularly spaced transects at each treatment location. Sampling intensity is at a maximum of 1 plot/acre for small sites up to 40 acres and at a minimum of 1 plot/acre for sites over 100 acres. For efficiency, a maximum of 40 plots are sampled at any site, regardless of size. Seedlings will be individually counted up to 25 per plot in three size classes: $\leq$ 12 inches, 1 – 6 feet, and > 6 feet. The first and second years of monitoring will provide immediate feedback on the initial phases of seedling recruitment. This early phase is threshold monitoring used to trigger a management response when a population drops below a certain desired level. Therefore the site may need to be re-treated if seedling density is below a desired level of 700/acre in the first or second year. Due to the longevity and the variable growth rate between and among the mesic conifer species and the relatively short 20 year project period, we cannot determine directly if mesic conifers are being recruited into the canopy of hardwood dominated sites. Therefore, we assume as an indicator for success that mesic conifers over 6 feet high will eventually reach the canopy. The success threshold after 5 years is a sapling density of 500/acre free to grow.

For research purposes, treatment success is measured by comparing replicated controls to replicated treatments (management prescriptions) and similarly among and between treatments. For efficiency of both time and resources, monitoring generally does not require replicated treatments and at best it will compare a treatment(s) to a control. Therefore, cause and effect of treatments can not be statistically inferred from monitoring data (The Nature Conservancy, 2001). The MC monitoring tracks changes within each individual site by comparing seedling/sapling survival data from a pre-treatment baseline to the first year after treatment to five, ten and up to 20 years. Recognizing the lack of replication and variability between suitable mesic conifer sites and prescriptions throughout the WUP, we chose to collect data on a limited number of key attributes: habitat type, overstory basal area, percent canopy cover, competition and browsing for each plot. Insights into treatment success may be suggested by pooling and analyzing the data over all sites and in different ways.

Monitoring will be done during late spring to early summer (late May to mid June) to be able to count seedlings, classify the habitat and determine herbaceous layer competition at the same time recognizing seedlings are most easily seen in late fall or early spring. Because the treatment area on any one site often will not conform to stand boundary, the treatment boundary is delineated using a GPS unit prior to initiating the prescription. GPS coordinates will enhance our ability to determine accurate treatment acreage and allow digital mapping of each site. GPS coordinates will also be taken for each plot during data collection phase and stored in the GPS

unit sequentially by plot number. The Lat/Long coordinates for each transect and sequential plot can be downloaded to an electronic data file later and matched with the hand written plot data.

Overstory basal area for all trees ≥ 2" dbh will be recorded separately for aspen, deciduous and conifer species. A visual estimate of percent canopy coverage will be recorded by cover class 1 = 0 - 25%, 2 = 26 - 50%, 3 = 51 - 75%, 4 = 76 - 100% for deciduous trees and conifers separately. Competition is approximated by percent vegetative cover and recorded in the same four cover classes as above for the following vegetative layers: grass/sedge, other herbaceous which includes ferns, and shrubs at two levels: greater than 1 - 6 feet in height and shrubs greater than 6 feet and greater than or equal to 2 inches dbh. Small tree seedlings less than a foot in height are to be considered part of the “other herbaceous layer”. Tree seedlings more than 1 ft. in height will be counted in the "Regeneration Attributes" part of the data sheet.

Regeneration attributes being recorded include conifer species, source origin of the seedlings: planted, seed, natural, or unknown. Seedlings will be counted as accurately as possible up to 25. More than 25 seedlings of a given species per source combination on a plot will be coded as 99 in the count column. Browsing data is captured by observing “yes” for each species per source combination if seedlings in that category have been browsed or “no” if not.

Analyzing Effectiveness Monitoring Data

Field monitoring data should be linked to the implementation monitoring database. It is possible the FMFMD "regen" forest regeneration database could be adapted for this purpose. Regen is a GIS that contains information concerning the location, and stocking of forest regeneration plots. Queries can be made spatially or through the access database it contains. Copies of stand level field data may reside with the local managers who will enter it into an appropriate access database.

As discussed above the first two years of data are used two-fold and are critical to the success of the project. The first, and most important, use is to be able to recognize if a threshold for successful seedling establishment based on a minimum mean number/acre or overall density based on spatial analysis is not reached and re-treatment will be required. The other use is to follow seedling/sapling survival trends over time for any given site.

As an added benefit of analyzing data for effectiveness monitoring, the mesic conifer project manager may gain insights into treatment effectiveness by analyzing the combined data and looking for patterns by comparing seedling and sapling survivorship data by MC species, size, source, habitat type, overstory basal area, competition, canopy coverage, and browsing. Using a GIS or spatial analysis may also suggest relationships based on location and other attributes not directly related to this project but residing in digital data layers of interest such as ecoregion or sub-sub section boundaries, snow fall zones, proximity to deer yards and so on. If patterns or insights emerge – research questions to further validate treatment and browsing effects may arise.

Resource Needs

Equipment needs include a GPS unit and the WUP Habitat Type Manual by Burger and Kotar (in prep.). (See Appendix B)Monitoring personnel will need to be proficient in habitat type classification to implement the protocol. Training in and access to the FMFMD "regen" forest regeneration database may be necessary. Regen is a GIS that contains information concerning

the location, and stocking of forest regeneration plots. Queries can be made spatially or through the access database it contains.

We recommend contracting for the field monitoring even though, initially, local resource managers could monitor their MC treatment sites. In each subsequent year new mc sites requiring monitoring are added. Assume, hypothetically, the same number of acres is treated each year to reach 57,000 acres in 20 years. In any given year, a minimum of 2,850 acres will be treated and monitored. In the second year monitoring will occur on 5,700 acres, the original 2,850 acres plus a new 2,850 acres. In year five, when the first treatments enter their third monitoring cycle, 8,550 acres will need monitoring. FMFMD currently lets contracts for regeneration monitoring with bids ranging from $5 to $10 per sampling plot. One person can sample approximately 50 plots per day. The MC monitoring cost per acre will be more and fewer plots can be sampled in a day because more attributes are being sampled, though not every acre will be sampled due to differences in sampling intensity (Appendix B). Assuming then in year five the potential sample acreage is half of what is actually treated or 4,275 acres, the cost for monitoring might range from $21,375 to $42,750 at $5 - $10 per plot. Multiple contracts would be required due to the short sampling season and the potential distance between monitoring sites.

Assessing Monitoring

Because we took a one size fits all approach to maximize efficiency in time and cost, we expect a large variation between and among species, treatments and sites. The first two years of monitoring should be considered a testing phase; whereby, based on data analysis, the monitoring protocol can be adjusted. For example, adjustments may be needed based on species due to differences in seedling distribution - less sampling may be needed for a white pine site and more for hemlock.

LITERATURE CITED

Albert, D. A. 1995. Regional landscape ecosystems of Michigan, Minnesota, and Wisconsin: A Working Map and Classification (4th Revision: July 1994) North Central Forest Experiment Station, Forest Service, USDA, St. Paul, MN. 250 pp

Bielecki, J. and R. Doepker, F. Krist, L. Pedersen, J. Pilon. 2003. Red pine community management on state forestland in Michigan. Michigan Department of Natural Resources (August 22, 2003 draft)

Burger, T. and J. Kotar. (*in prep*). A guide to forest communities and habitat types of Michigan, Section 3 (Department of Forest Ecology and Management, University of Wisconsin-Madison.

Coffman, M. S., E. Alyanak, J. Kotar & J. Ferris. 1984. field guide habitat classification system for Upper Peninsula of Michigan and Northeast Wisconsin, Michigan Technological University, Houghton, MI

Doepker, R. et al. 2001 Interim State Forest Management Guidelines to Emphasize Mesic Conifers in the Western Upper Peninsula, Michigan Department of Natural Resources.

Frelich, L. E. 2002. Forest dynamics and disturbance regimes. Cambridge University Press, Cambridge, UK 266 pp

Kotar, J. and M. Coffman. 1984. Habitat-type classification system in Michigan and Wisconsin. In: Bockheim, J.G., ed. Forest land classification: experiences, problems, perspectives: proceedings of the symposium; 1984 March 18 - 20; Madison, WI. Madison, WI: University of Wisconsin: 100 - 103.

Kotar, J., J. A. Kovach, C. T. Lacy. 1988. Field guide to forest habitat types of Northern Wisconsin, U of W – Madison & Wisconsin DNR.

Mlladenoff, D. J. and F. Stearns. 1993. Eastern hemlock regeneration and deer browsing in the Northern Great Lakes Region: A re-examination and model simulation. Conservation Biology 7(4). 889 – 899.

Mech, R. and J. Bielecki. 2001. Forest regeneration survey manual. Forest, Mineral and Fire Management Division, Michigan Department of Natural Resources. Lansing, MI. 23 pp.

The Nature Conservancy. 2002. Vegetation monitoring in a management context. Natural Areas Training Academy. Gainesville, FL.